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ABSTRACT

A university consortium recently undertook a project designed to explore the use of technology in teaching high school biology as a means of engaging students actively in the scientific method, and in changing the role of the teacher from lecturer and conclusion drawer to initiator and facilitator. The study examined the degree to which teachers fulfilled the intended role in a classroom setting in which a single computer was an integral part of the presentation of the lessons. Materials were developed to be presented by computer to an intact class of students, and interest centered on the computer's effect on teachers' instructional behavior, especially their asking behavior. Results indicated that the use of a single computer in a whole class setting is a viable instructional model. Teacher question-asking behavior seems to be able to be modified by the use of the computer, since teachers in this study tended to ask more high level inquiry questions than traditionally reported in the literature. Examples of questions in the high and low level inquiry categories asked by the teachers are included in the appendix. (TW)

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Paper presented at the National Association for Research in Science Teaching Annual Meeting, April 24, 1987.

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Teacher Behavior In Whole Class Computer-Mediated Instruction.

Purpose: This study was designed to examine teacher behavior in a classroom setting in which a single computer was an integral part of the presentation of the lesson. The study was one element of a research project conducted by the Rhode Island/Brown Technology Consortium, a subproject of the Educational Technology Center at Harvard University. This project developed materials to be presented by computer to an intact class of students. Teachers using these materials were expected to shift their role from lecturer and conclusion drawer to initiator and facilitator. This study examined the degree to which teachers fulfilled the intended role.

Theoretical Basis: The Rhode Island/Brown Technology consortium had undertaken a project to explore the use of technology in teaching high school biology as a means of engaging students actively in the scientific method and changing the role of the teacher from lecturer and conclusion drawer to initiator and facilitator. The computer classroom materials developed for use in this project appear to resemble those advocated by Schwab (1960). Although the "Invitations to Inquiry" found in the Biology Teachers' Handbook (Klinkmann, 1970) were not used as a model for the development of materials, the resulting computer materials represent an interactive, computer based implementation of this type of instructional material. In the material, students are presented information by the computer and key questions are asked by the computer. Students are provided several options as to the information or experiments that could be explored. The teacher's job is to moderate the discussion, calling on students, asking additional questions, and arbitrating disputes. The biology content of the lesson is drawn from

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genetics. The lesson focuses on hypothesis the inquiry skill of testing.

The project was interested in the extent to which the presentation of information by the computer could facilitate a change in teacher behavior, especially the teacher's question asking behavior. Evans (1973) had shown that teacher instructional behavior is very resistant to change. Ladd and Andersen (1970) had proposed that teacher questioning behavior might best be considered in two broad categories, low level and high level inquiry. Balzer (1973) and Gall (1984) had shown that while biology teachers often asked lots of questions, only about 20% of their questions could be classified as high level inquiry questions.

Project Developed Materials. The project developed materials consisted of a computer program disk with four instructional programs to be used in sequential fashion, a student data sheet, suggested homework problems, and a teachers guide. The computer materials were developed for use on Apple II computers. The four programs (lessons) were designed to be used in conjunction with a genetics unit. In lesson one, students taste treated papers, and class data are collected and entered into the computer. Students are then asked to explore the tasting phenomenon by examining data from other classes and other populations. Students are presented with three hypotheses which are to be evaluated by use of the data. During this activity students should begin to develop a sense of the use of falsification in testing hypotheses. Lesson two introduces a series of hypothetical males and females who may be "married." Students know whether each parent is a "taster" or "non-taster." A batch of children (20 per marriage) is produced and the number of tasters/nontasters examined. Again, hypotheses are presented by the program and students use the resulting data to evaluate them. In lesson three, in a hypothetical situation, "tasters" and "nontasters" tribes migrate from isolated islands to a new island and then interbreed, producing only tasters. Students may then breed second generation crosses and backcrosses to test additional hypothesis about tasting. In the final lesson, the hypotheses focus on explaining the observed phenomenon of the previous lessons. Different hypothetical models are examined for their possible use in explaining the data. Finally a two bit model with independent assortment of traits is found acceptable for explaining the data, while all other hypotheses have been rejected.

Procedure. Project materials were used by eight teachers in one or two of their classes. In all classes only one computer was used. A Sony video projector presented a large display for the entire class, and a small monitor provided the computer operator (teacher or student) with an output display . In order for the projection screen to be visible in the room, the classroom was darken. Two biology teachers used the materials prior to students encountering genetics, three biology teachers used the materials after their classes had studied genetics and three science teachers used the materials with students who would be studying biology next year. In each class, use of the materials extended for three or four days. Each teacher was videotaped for one of their classes each day. All teachers were observed by one or more project staff members for each lesson.

Data were collected from several sources. The videotapes were reviewed and a record of all teacher questions was made. All teacher questions were classified as high or low level inquiry. The resulting data were examined for differences between teachers and between settings in which the materials were used. The data were also compared to existing records of biology teachers' questioning behavior. Other data used in this analysis included a post teaching questionnaire completed by the teachers, a group interview/debriefing session with the project teachers, a student questionnaire and project staff observations of the classes.

Results and conclusions. The most quantifiable data from this research project focused on teacher questioning behavior. Table 1 indicates the number of questions asked per teacher per lesson and provides the average number of questions asked by each teacher in each lesson. Teachers averaged asking 43 to 93 questions per class. Classes averaged slightly more than 50 minutes, but could have been as short as 40 minutes or as long as 75 minutes. The number of questions asked was greater than anticipated by the project staff, but was only somewhat lower than the 45–150 questions per half hour Hyman (1980) reported teachers ask. The numbers of questions asked by teachers differed. This is confirmed by a series of Chi-Square analyses which showed teachers differed from each other in the number of questions asked per lesson, and that for all teachers, except Teacher H, teachers differed in the number of question they themselves asked from lesson to lesson.

Table 1: Total Number of Questions Asked per Teacher Per Lesson

Teachers	Lessons 1	2	3	4	average
A	75	13	116	109	78.25
B	139	84	57	*	93.33
C	76	78	80	25	64.75
D	44	55	101	*	66.67
E	32	24	95	44	48.75
F	56	30	54	34	43.50
G	65	*	139	69	91.00
H	48	49	48	*	48.33
Average/lesson	66.88	47.57	86.25	56.20	64.22

The differences appear to be related to individual teacher differences; no differences were found based on the prior experience of students or the school of the teacher.

The computer may be providing a common stimulus to the whole group instructional activity, but these data make it apparent that when teachers are using the same instructional modality, substantial teacher to teacher differences remain.**

*Missing Data: In one school, lesson two was not used in the lesson sequence. In one school the fourth lesson was cancelled by snow, in two schools video taping was not completed for the fourth day.

** Project staff had anticipated that the computer use could substantially reduce the number of questions asked by the teacher. Many teacher often rephrased and reasked questions from the computer program.

Table 2 indicates the proportion of each teacher's questions per class which were classified as high level inquiry. (See the Appendix for a sample of class questions and their classification).

Table 2: Proportion of High Inquiry Questions Asked per Teacher Per Lesson

Teachers	Lessons 1	2	3	4	all lessons
A	.37	.31	.51	.61	.50
B	.36	.45	.39	*	.40
C	.43	.59	.36	.36	.45
D	.45	.55	.43	*	.47
E	.41	.33	.38	.25	.35
F	.41	.43	.46	.41	.43
G	.37	*	.49	.29	.41
H	.38	.49	.77	*	.38
Average/lesson	.40	.44	.43	.38	

Teachers asked a total of 1839 questions. Of these 811, or 44% were classified as high inquiry. Teachers varied in the percentage of high inquiry questions they asked. As shown in Table 2, teachers asked as low as 25% to as high as 77% high inquiry questions in individual lessons. The averages for each teacher for the four lessons ranged from 35 to 50% of the questions they asked.

* See note on missing values previous page.

Because the numbers in Table 2 are frequencies, they mask the absolute number of high inquiry questions asked by teachers. When the numbers of high inquiry questions each teacher asked per lesson are examined, substantial variation is found. The fewest number of high inquiry questions asked by a teacher was 4 (teacher A, lesson 2); the highest number was 68 (teacher G, lesson 3). The average number of high inquiry questions was 28.

Again, the project staff would question the use of 66 "high inquiry" questions in one class period. When "high inquiry" questions are asked with a frequency of one-per-minute, there are other attributes of teacher questioning behavior that probably should be examined.

The observed frequency of high inquiry questions is approximately double the percentage of high inquiry questions Balzer (1973) and Gall (1984) reported that teachers ask. The data above were inspected for possible differences in teacher questioning behavior based upon the school of the teacher and the place of use of the materials in the curriculum. No systematic differences were found.

Teacher reports, project staff observations, and student questionnaire data was reviewed by project staff. The following summarizes the findings of this review.

> The computer can be the focus of attention. Students can attend to the computer presentation, they can follow its instructions, and they can respect its judgements about their responses.
>
> Teachers are not immediately comfortable with the computer as the center of attention. During the group interview teachers identified several adjustments they had to make. For example, one teacher found it difficult to lead a class discussion when the students' eyes were directed at the projection screen.
>
> This mode of instruction appeared to promote student discussion and consideration of diverse views. However, observers noted that many accepted teacher behaviors to promote student discussion did not occur. For example, teachers did not

use wait-time and teachers always intervened between student responses.

Teachers did not readily comprehend the instructional emphasis of the materials. All teachers using the materials had participated in at a day of training with project staff. Yet, the teachers tended to view the content as genetics and not as hypothesis testing. Even when hypothesis testing was the focus of the teachers actions, project staff wondered about the degree to which teachers understood hypothesis testing.

This mode of instruction appeared to lose its effectiveness over time. By days three and four, many students had lost interest in the lesson and teachers did not have effective ways to re-engage them in learning. Teachers felt they were dominated by the computer and did not have knowledge of techniques to effectively share "teaching" with the computer.

Teachers did not have a convenient way to get in and out of segments of the computer lesson. The computer lessons used were primarily linear in their overall presentation. The computer rather than the teacher dominated the structure, though not necessarily the delivery of the lesson. The computer had the obvious control over the sequence of the material. Often teachers were heard to apologize for not "following" the computer script, e.g. asking a question one frame before the computer asked for it. When teachers were asked for the percent of control that the computer had versus the control they had over the lesson, they thought the computer had about 80% of the control. Conversely, when the observers were asked the same question they felt the teacher had about 60% control.

Students reported that these lessons differed from their regular instruction in the way the computer was used in class and in the increased amount of class discussion that occurred.

Teachers indicated that they would like to use the computer in the same instructional style in their classes again.

Teachers, project staff and students appeared to favor occasional, single class lessons in this instructional mode rather than its use in a sequence of classes.

Implications. This project has shown that the use of a single computer in an instructional role in a whole class setting is a viable instructional model. From the data collected in this project it appears that teacher question asking behavior can be modified by the use of the computer. Teachers asked more high level inquiry questions than traditionally reported in the literature. Teachers also asked slightly fewer questrions than usually reported in the literature. In these lessons the computer was given the role of the information authority while the teacher was freed to assume a facilitator role. However, teacher-to-teacher behavior differences occurred in this instructional setting. These differences included both the number and type of questions aksed. While the single computer/whole class model is viable, many questions remain to be explored. The fact that the teacher remains the important element in this instructional mode means that more attention must be given to answering the dual questions "What should the computer be doing? What should the teacher be doing? One possible guideline to answering these questions is to consider the computer as the information authority in the classroom and the teacher as the instructional authority.

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H. 73. Yes, but how do you prove it?

L. 74. You think that the sex has something to do with it?

(computer asks : can you conclude anything from this?)

H. 75. Now, how do you explain this?

H. 76. You think it has to do with the male? How are you going to prove it?

L. 77. Do it again - what are you going to do?

L. 78. OK, what would you like me to do?

L. 79. What do you want to cross?

RHETORICAL -80. Aren't you glad you came here today?

H. 81. Try to explain what's going on, can you? Do you have any ideas?

H. 82. What was the %? How do you explain that? What can you say?

H. 83. Do we have any ideas as to why this is happening?

L. 84. None at all?

H. 85. If that's true(student suggested that traits skip generations) do you know how that could happen at all? Is there any explanation as to how it can stop and then just go on? Stop and go on, can it do that?

H. 86. Would more testing help?

H. 87. Would it help us to do more combinations?

H. 88. Could we find a pattern?

H. 89. What can you do?

H. 90. Can anything be concluded from what you've just seen?

H. 91. If that's so(things can be passed on) why does it show up some of the time and not all of the time?

L. 92. What did you conclude from looking at different populations? What is the average?

L. 93. Did you have a % on that at all?

L. 94. How many came out 75-25%?

2nd day.

L. 95. What did we finally arrive at? What did we come up with as a norm?

L. 96. What combinations did we find?

L. 97. We did it again, what did we get?

H. 98. What does that say to us?

H. 99. Do we know that for sure?

H. 100. Do we have any evidence of that?

L. 101. Any questions before we begin today- about what we did yesterday?

------(goes to the islands)----------

H. 102. Could somebody comment?

L. 103. What happened to the nontasters?

H. 104. What do you think?

H. 105. Go back to what you said. How can we explain this?

H. 106. Did you hear what she said?(then repeats student's answer). N--? What do you think?

L. 107. A taster would have one tasting part and what?

L. 108. No chance?

L. 109. What are our ratios? Our ratios are coming up what?

H. 110. Why aren't the children the way they were on taster island?

H. 111. How is that possible? If you didn't have it, how can you pass it on?

(computer prompts that this is not necessary)

H. 112. Explain to me why. Why do we not have to perform this experiment?

H. 113. Why?

(another example-results)

H. 114. Why? How is it possible?

H. 115. Do you have enough information to put together an hypothesis? Would you like to see more?

- 116. Do all of you, and I can see that you don't, understand some of this? Because if you don't, I want some other combinations of crosses from the rest of you

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L. 117. T2? and what?

L. 118. Anyone else?

H. 119. Does this follow?

H. 120. Is this consistent with that hypothesis?

(another hypothesis- look at example on computer)

H. 121. Is this consistent?

H. 122. J--, do you think so? Make a judgement on what you see only.